

## **EXHIBIT M**

### **O&M MANUAL FOR BIOFOR BIOSTYR AND DENSADEG**

**Refer to Phase I Protocol Biofor and  
Biostyr O&M Manual**

**DENSADEG® PILOT PLANT  
OPERATION INSTRUCTIONS**

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## I. GENERAL

The DensaDeg® treating plant is a high-density solids-contact clarification unit which incorporates the processes of flocculation, liquid-solids separation, sludge recycle, and thickening.

## II. Equipment and Operation Description:

An understanding of the specialized zones and the functions of various components are essential to the understanding of the operation of the treating plant.

### A. DensaDeg® Clarifier:

#### *1. Rapid Mix Tank*

The rapid mix tank is the zone of coagulant addition and high speed mixing. Raw water is pumped to the top of the tank where the coagulant is introduced. A variable speed mixer increases the particle energy as water flows down through the tank and to the reactor tank.

#### *2. Reactor Tank*

The reactor tank is the zone where flocculation occurs. The reactor tank consists of a round tank with a reactor tube and turbine mixer. Influent and recycled sludge from the thickener zone of the DensaDeg® combine before entering the unit. This mixture flows through the influent pipe into the bottom of the reactor tube. Polymer is introduced into the mixture within the reactor tube. The turbine mixes the liquid with previously formed precipitates and pumps the liquid upward, inducing a cardiac profile in the reactor tank of the DensaDeg®.

Continued contact promotes efficient chemical usage and the growth of a denser floc. Between the reactor tank and the clarifier tank is a baffled transitional zone. As the slurry is displaced by incoming liquid, a portion of the slurry moves upward between the reactor and clarifier tanks.

This slurry passes over a submerged weir and into the clarifier/thickener vessel. It is essential in this zone that minimum uplift velocities are maintained to prevent solids from depositing on the floor of the reactor tank.

### **3. Clarifier Thickener Vessel**

#### Presettling / Thickener Zone

In this zone, the flocculated solids (sludge) are settled and concentrated for return to the primary reaction zone and for waste sludge withdrawal. A floor scraper keeps the sludge in a fluid state and moves it to a central draw-off sump.

#### Clarification Zone

In this zone, clarified water rises up through the lamellar settling tubes and into the effluent launder for discharge of the clarified effluent downstream to the Packaged Gravity Filter.

#### **B. DensaDeg® Drive:**

A reaction tank turbine drive and clarifier floor scraper drive are supplied for rotating the internal machinery.

The reactor turbine drive is a variable speed drive. The actual final operating speed will be determined during process optimization, at startup. The clarifier/scraper drive is a variable speed unit comprised of several speed reducers.

#### **C. Sludge Recirculation and Sludge Discharge to Waste:**

The sludge recirculation pump is used to control external sludge flow. Its main purpose is to recycle solids from the thickener unit back to the primary mixing and reaction zone.

The concentration and quantity of sludge recycled to the reactor tube must be adjusted to optimize treatment. Adjusting the quantity may be accomplished by adjusting the flow through the recycling pump. It is important to adjust the recycling rate appropriately to accommodate any fluctuation in the influent flow rate. Adjusting concentration can be accomplished by changing the height of the sludge recirculation draw-off funnel. (During start-up sludge can be recycled from the sludge-blowdown area.)

The waste sludge will be removed as required to maintain the desired sludge inventory and density. Blowdown can be controlled by either a timer (via input based on the influent rate) or manually. The length of blowdown is adjustable via a timer in the PLC.

**D. Sample Connections:**

A vertical row of sample connections on the side of the clarifier tank provides samples from various levels in the sludge settling zone for determination of the sludge concentration at these levels.

They are also used to determine the elevation of the top of the sludge blanket, and thereby guide the operator in the need to adjust sludge blowdown.

**III. Start-up:****A. Equipment Checks:**

1. Inspect the DensaDeg® tank and mechanism thoroughly, removing all debris that will interfere with sludge recirculation, sludge blowdown or mixer rotation.
2. Ensure that all pumps, drives, reducers, etc. are properly lubricated.
3. Ensure that the raw water and recycle sludge pumps are operating correctly.
4. Ensure proper rotation of the reactor turbine and scraper drive.
5. Ensure that the scraper drive is free to rotate and is not obstructed in any way.
6. Ensure that all chemical feed systems are operational.
7. Ensure that all piping has been blown out and cleared of debris.

**B. Initial Operation:**

Prepare chemical feeding systems by filling with chemicals and calibrating feed rates. Start the chemical feed units with the raw water flow. Adjust the chemical feed pumps for the proper feed dosages. Start the reaction turbine as soon as the reaction tank is filled. The sludge scraper drive is started when the settling zone is filled.

Start the recycle flow through the sludge recirculation pump as soon as the DensaDeg® is full of water.

The period of initial operation is characterized by a gradual build-up in the concentration of solids and in the density of the slurry. During this period, it is advisable to operate at approximately 50% of the designed rate of flow for greater retention of solids while the particle size is small. Do not blow down sludge from the unit until it has developed a suitable sludge inventory. However, as soon as a reasonable sludge inventory is obtained,

automatic or periodic sludge blowdown should commence at the rate required to maintain the desired sludge density and inventory.

The time required to establish a normal sludge inventory varies depending upon the suspended solids in the raw water, the degree of treatment desired, and the type of coagulant agents used. The time may be as short as 6 to 8 hours or as long as several days, especially if operation is intermittent.

#### **IV. Normal Operation:**

##### **A. Shutdown:**

If shutdown of the unit is necessary, stop sludge recycling 5 to 30 minutes prior to shutdown.

For a **short-term shutdown**, allow the mixer and scraper drives to continue to operate.

For **prolonged shutdown** (1 or more days), stop the turbine.

Remove all sludge from the tank. Stop the scraper after the sludge has been removed. The scraper must operate as long as any sludge remains in the tank. If possible, keep the DensaDeg® Clarifier flooded to protect the lamellar tubes from direct sunlight. Flush all sludge lines.

##### **B. Start-Up Following a Shutdown:**

To restart the plant after a normal shutdown, start up the DensaDeg® drive, the sludge recirculation pump, all automatic controls, and chemical and raw water feeds. Verify that each system is functioning normally.

##### **C. Control of Operation:**

It is important that sludge levels and concentrations are controlled in the various zones of the DensaDeg® plant. Refer to the following sections on Reactor Slurry Concentration, Sludge Inventory Control, and Effluent Turbidity for a detailed description of operational adjustments. This data should be recorded at least once every 8 hours of operation.

Sample data, for record, should be taken when the operation is stabilized and used to detect abnormal variations on a day-to-day basis.

**D. Coagulant Dosage:**

The effectiveness of various coagulants or coagulant aids can be determined by jar testing. Note: Experience has shown that both coagulant and coagulant aid may be reduced below levels determined in initial jar testing. Constant monitoring can not be overstressed.

**V. Reactor Sludge Concentration:**

A modest concentration of solids in the reactor is necessary to promote and complete the desired floc formations. The amount of solids that is required for best treatment should remain uniform once process equilibrium has been established.

The concentration of reactor solids must be monitored to ensure proper operation. The concentration of reactor solids should be between 0.050.2% by weight.

A quick method for determining proper reactor solids concentration is by a 10 minute settling test. This method should be used for quick on- site analysis. Gravimetric analysis will yield more precise results.

1. Take a representative sample from the reactor tank in a 100 ml graduated cylinder.
2. Allow sample to settle for 10 minutes.
3. Observe the settled sludge volume. If, for example, the reading is 15 ml, then the sample is 15% solids by volume.

The range of sludge concentrations that produce the best results for your installation are dependent upon local conditions, primarily the characteristics of the water to be treated and the treatment results desired as well as the nature and quality of coagulation chemicals. They cannot be precisely predicted. Only on-site experimental adjustments during early system operation can develop the data best suited for continuous operation guides.

A significant change in the volume or density of the solids indicates an abnormal condition that must be corrected. If the solids concentration decreases while there is an increase in the depth of the sludge zone, the treatment and coagulation may be incorrect. Perform tests and correct the treatment if necessary .

**VI. Sludge Inventory Control:**

The depth of the sludge bed is determined by taking samples from the taps on the tank wall. Samples drawn from highest tap should be essentially free of sludge at all times. If sludge appears at this sample tap, check the chemical feeds and correct if necessary . If

the chemical flows are correct and sludge persists at the highest tap, the unit contains too much sludge. Increase the sludge blowdown slightly.

The factors which can cause a change in the sludge blanket depth are:

1. Change in the frequency and/or duration of sludge discharge.
2. Change in the characteristics or temperature of raw water .
3. Change in the chemical treatment.
4. Change in reactor zone sludge density .
5. Change in raw water flow rate.

Flocculated solids in excess of the amount required for circulation to the reactor are continuously removed from the unit. The amount of solids discharged must equal the amount of solids formed during treatment. If the amount discharged is less than the amount produced, the sludge depth will increase and the solids may carryover in the effluent, or the sludge may compact, de-flocculate, and overload the floor scraper system. If the amount discharged is greater than the amount produced, there will not be adequate sludge for circulation to the primary reaction zone. The depth will decrease and the density may decrease.

It is helpful to know the instantaneous flow rate of sludge blowdown to assist in selecting blowdown timer settings. Time the rate of drawdown in the tank while the unit is idle or catch a timed volume during blowdown and calculate the flow in gallons per second.

## **VII. Effluent Turbidity:**

Suspended solids in the effluent liquid can be monitored by conventional filtration and Gravimetric analysis at least once every 8 hours.

Excessive effluent turbidity can be caused by:

1. Excessive sludge depth
2. Excessive sludge recycle
3. Insufficient sludge discharge
4. Incomplete coagulation or chemical treatment
5. Chemical feed failure
6. Sudden swings or changes in raw water flow

Check all phases of operation thoroughly when this condition exists.

### **VIII. Maintenance:**

Lubricate all motors, gear reducers, and accessory equipment as directed in the accompanying instructions. Inspect the sludge valve, timers, and proportioning devices periodically to see that they are operating properly. Lubricate them and clean them as directed in the accompanying instructions. IDI recommends that the head of operations prepare maintenance summary sheets, specifying specific schedules with specific actions.

#### Suggested DensaDeg® Operating Record

		Date						
Chemical Tests								
Raw Water	Turbidity							
	Hardness							
	P Alk							
	M Alk							
	A							
	Turbidity							
Effluent	Hardness							
	P Alk							
	M Alk							
	A							

#### Chemical Treatment

Soda Ash							
Lime							
Sodium Hypochlorite							
Polymer							
Ferric Chloride							
Sulfuric Acid							
Primary Zone Sludge							
Sludge recycle							
Sludge discharge							
Sludge Blowoff							
Raw water flow							

## I. TROUBLESHOOTING GUIDE

The most common operational problems and remedies are shown in the following tables. Depending on the facility in question or the type of treatment involved, the remedial actions recommended may be modified or supplemented.

PROBLEM	PROBABLE CAUSE	ACTION
<b>REACTOR</b>		
<i>Percentage of sludge in reactor too low.</i>	Recycling Flow Rate too low.	Check sludge recycling pumps for proper setting. Increase flow if necessary.
	Recycling pump stopped or not set correctly.	Check setting. Adjust as necessary. Note that flow increase does not systematically lead to a rise in % of sludge. Maximum of recycle mass flow often occurs at fairly low levels.
	Recycling pump clogged.	Unclog with pressurized water.
		Check electrical interlock.
		Check variable frequency drive - refer to vendor literature section of this manual.
	Mixer stopped or not functioning properly.	Sludge deposits can form during shutdown, blocking the mixer. Decrease the influent flow rate and lower an air or water injection rod into tank to suspend the settled solids. If this is ineffective, stop the influent flow and partially drain the tank to remove excess solids.
		Check coupling bolts. If loose, tighten.
		Check gearbox. Refer to vendor literature.

PROBLEM	PROBABLE CAUSE	ACTION
REACTOR		
Percentage of sludge in reactor too low. (con't)	Lack of coagulant.	Ensure correct amount of coagulant is being fed. Refer to vendor literature section of this manual.
	Sludge level down.	See following Clarifier troubleshooting section.
		Check quality of polymer, date of preparation, concentration.
	Not enough polymer. Treated water cloudy or floc rising to surface.	Check polymer feeder for proper operation. Refer to the vendor literature section of this manual.
		Check injected and diluted concentration.
	Too much polymer. Sludge level drops, deposits in reactor.	Check polymer dose and flow rate. (This is more probable at low flow rates.)
<i>Percentage of reactor sludge very high.</i>	Recycling flow rate too high.	Check sludge recycling pumps for proper setting. Reduce flow if necessary.
NOTE: when the flow is less than the normal flow, the sludge percentage will be higher, since the plant operates on a constant sludge mass flow.	Sludge blanket rises.	Check sludge level in settling tank.  Check setting of the sludge removal pumps.  Check polymer feed.  If necessary, lower sludge level. Increase sludge removals. Utilize lower level sludge drawoff valves.

PROBLEM	PROBABLE CAUSE	ACTION
<b>CLARIFIER</b>		
<i>Sludge level too high.</i>	Insufficient sludge removal.	Increase sludge removal rate.
	Polymer or dilution deficiency (sludge blanket expansion).	Check and adjust polymer feed. Refer to 2.7 in this section.
	Scraper stopped.	Check and adjust.
		Check raw water flow rate.
	Massive increase in raw water load.	If necessary, rapidly lower sludge level by forced removal in manual or auto modes.
<i>Sludge level low.</i>	Sludge level too low.	Check actual sludge level (take samples).
	Excessive sludge removal.	Check pumps, reduce flow rate if necessary
	Too much polymer.	Check and adjust.
	Scraper stops.	Check and restart.
	Recycling stopped or defective.	Check and restart.
	Drastic Drop in Raw Water Load.	Check. Modify settings.
<b>SCRAPER</b>		
<i>Scraper overtorque - alarm condition.</i>	Sludge concentration very high.	Increase rate of sludge removal. Check chemical dosing rates. Make sure they are not too high. Check concentration of removed sludge.
	Removal intervals too long.	Remove sludge by manual operation. Adjust sludge removal intervals.

PROBLEM	PROBABLE CAUSE	ACTION
SCRAPER		
<i>Scraper overtorque - alarm condition.</i>	Too much sludge in settling tank	Refer to 2.1 in this section
	Sludge residence time too high.	Check sludge recycling pumps for proper setting. Decrease flow if necessary.
	Bottom sludge concentration too high.	Sludge on floor more concentrated than for removal. Increase scraper speed.
<i>Scraper overtorque - shutdown condition.</i>	Scraper overtorque alarm troubleshooting ineffective.	Review scraper overtorque alarm troubleshooting.
	Sludge removal too infrequent.	Adjust sludge removal intervals.
	Sludge concentration abnormally high.	Check sludge recycling pumps for proper setting. Decrease flow if necessary.
	Scraper blocked by foreign object.	Drain tank and fix. See 2.1 in this section.
<i>Sludge concentration under modules is high.</i>	Sludge level too high.	Increase frequency and duration of sludge removals.
	Sludge % in reactor too high.	Check, lower if necessary. See 2.5.
	Lack of coagulant.	Check coagulant feed rate. Adjust as required.
<i>Treated water cloudy.</i>	Reactor sludge percentage insufficient.	Refer to 1.1 in this section.
	Lack of coagulant.	Check and adjust.
	Lack of polymer.	Check and adjust.
	pH too high or too low.	Check and adjust.

PROBLEM	PROBABLE CAUSE	ACTION
SCRAPER		
<i>Treated water cloudy.</i>	Sludge fermentation - residence time too long.	<p>Forced sludge removal.</p> <p>Replenish sludge supply.</p> <p>Use lower sludge drawoff valve.</p> <p>Increase sludge removal.</p> <p>Increase scraper speed.</p>
	Reactor bottom heavily clogged (can occur with frequent stops without stop procedure or feed rate too low).	<p>Clean deposits from bottom of the reactor as follows:</p> <ol style="list-style-type: none"> <li>1. Increase impeller speed to put solids into suspension.</li> <li>2. If #1 ineffective, decrease the influent flow rate and lower an air or water injection rod to the bottom of the reactor tank to suspend the solids.</li> <li>3. If #2 ineffective, stop influent flow and partially drain the reactor.</li> </ol>
	Mixing reactor stopped.	Check, re-start.
	Mixing reactor rotation speed too slow (inadequate power) or too high (floc breakup).	Check, adjust.
	Scraping speed too high (breaks up floc).	Reduce speed.
	Raw water pollution variation.	Perform analysis and jar tests.

PROBLEM	PROBABLE CAUSE	ACTION
SCRAPER		
<i>Local rise offloc.</i>	Beginning of choking.	Refer to 2.7.
		Check Sludge level. If too high, see 2.1.
	Uneven settling in lamellar area. Note: At low flow rate, there may be slight distortion due to turbine influence without affecting treatment quality .	Inspect the area beneath the modules. If sludge present (% > 1) refer to section 2.4.
		Make sure reactor is not partially clogged. Consider cleaning of reactor. See section 2.5 for other actions.
		Reduce turbine rotation speed.
		Check neoprene drape to ensure that no large openings exist.
<i>Modules clogged.</i>	See 2.1,2.4, 2.6.	Stop flow of raw water to DensaDeg®.  Allow to clarify for 1/2 - 2 hrs.
		If sludge remains in modules, clean modules by slowly draining the modules while cleaning the deposits with a hose.
		See section 2.7.
<i>Algae development in module.</i>	Prolonged shutdown and sunlight.	Break up algae with a water jet or similar means as the water is drained.  If the above is inadequate, disinfect with chlorine bleach (50 g/m <sup>3</sup> to 100 g/m <sup>3</sup> of chlorine in static conditions (1 to 2 days).
	Raw water quality.	Raw water analysis should be surveyed constantly.

## **EXHIBIT N**

### **BROWN AND CALDWELL HEALTH AND SAFETY PLAN**

**Refer to Phase I Protocol**

## **EXHIBIT O**

### **PLWWTP CONTINGENCY PLAN (November 19, 2003 Version)**

**Refer to Phase I Protocol**

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B R O W N   A N D  
C A L D W E L L

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Appendix E. Phase I and Phase II  
Lab Analysis Results  
Meter and Pilot Instrument Readings  
Pressure Plots



















